**BASIN ELECTRIC
POWER COOPERATIVE**

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April 10, 2000

Mr. William Grimley
Emission Measurement Center (MD-19)
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

Attn: Electric Utility Steam Generating Unit Mercury Unit Test Program

Dear Mr. Grimley:

Enclosed are two (2) copies of the Stack Test Report for the Speciated Mercury Emissions Testing at the Basin Electric Power Cooperative Laramie River Station Units 1 and 3.

If you have any questions or comments as to the contents of this test report please contact me.

Sincerely,

Jerry Menge
Air Quality Program Coordinator

jm:mev
Enclosure
cc: Dan Olson,
WY Department of Environmental Quality w/encl.

SPECIATED MERCURY EMISSIONS TESTING

Performed For
BASIN ELECTRIC POWER COOPERATIVE

At The
Laramie River Station
Unit 1
Scrubber Inlet and Stack
Wheatland, Wyoming

September 20 and 21, 1999

Mostardi Platt

Mostardi-Platt Associates, Inc.
A Full-Service
Environmental Consulting
Company

945 Oaklawn Avenue
Elmhurst, Illinois 60126-1012
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MOSTARDI PLATT PROJECT 93859
DATE SUBMITTED: MARCH 23, 2000

CERTIFICATION SHEET

Having supervised and worked on the test program described in this report, and having written this report, I hereby certify the data, information, and results in this report to be accurate and true according to the methods and procedures used.

Data collected under the supervision of others is included in this report and has been gathered in accordance with the procedures outlined in the Quality Assurance Project Plan.

MOSTARDI-PLATT ASSOCIATES, INC.

Bruce Randall

Bruce Randall mga
Regional Manager

Reviewed by:

Scott W. Banach

Scott W. Banach
Director, Project Engineering

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1.0 INTRODUCTION

1.1 SUMMARY OF TEST PROGRAM

The U.S. Environmental Protection Agency (EPA), is using its authority under section 114 of the Clean Air Act, as amended, to require that selected coal-fired utility steam generating units provide certain information that will allow the EPA to calculate the annual mercury emissions from each unit. This information will assist the EPA Administrator in determining whether it is appropriate and necessary to regulate emissions of Hazardous Air Pollutants (HAPs) from electric utility steam generating units. The Emission Measurement Branch (EMB) of the Office of Air Quality Planning and Standards (OAQPS) oversees the emission measurement activities. Braun Intertec Corporation (Braun Intertec) conducted the emission measurements. Mostardi-Platt Associates, Inc. (Mostardi Platt) was retained by Braun Intertec to complete the report.

EPA selected Unit 1 at the Basin Electric Power Cooperative (BEPC) Laramie River Station (LRS) in Wheatland, Wyoming as one of seventy eight coal-fired utility steam generating units who would be required to conduct emissions measurements. The test was performed at LRS Unit 1 on September 20 and 21, 1999. Simultaneous measurements were conducted at the inlet and outlet of the Wet Scrubber. Mercury emissions were speciated into elemental, oxidized, and particle-bound mercury using the Ontario-Hydro test method. Fuel samples were also collected concurrently with Ontario-Hydro samples in order to determine fuel mercury content.

1.2 KEY PERSONNEL

The key personnel who coordinated the test program and their telephone numbers are:

- Braun Intertec Project Manager - Bruce Randall (651) 686-0700
- Braun Intertec Test Director - James Tryba (651) 686-0700
- BEPC Air Quality Program Coordinator - Jerry Menge (701) 223-0441
- BEPC AVS Plant Contact/Process Monitor - Terry Archbold (307) 222-9601

2.0 PLANT AND SAMPLING LOCATION DESCRIPTIONS

2.1 PROCESS DESCRIPTION

Figure 2-1 illustrates the basic operational steps for this coal-fired steam generator. The steps are:

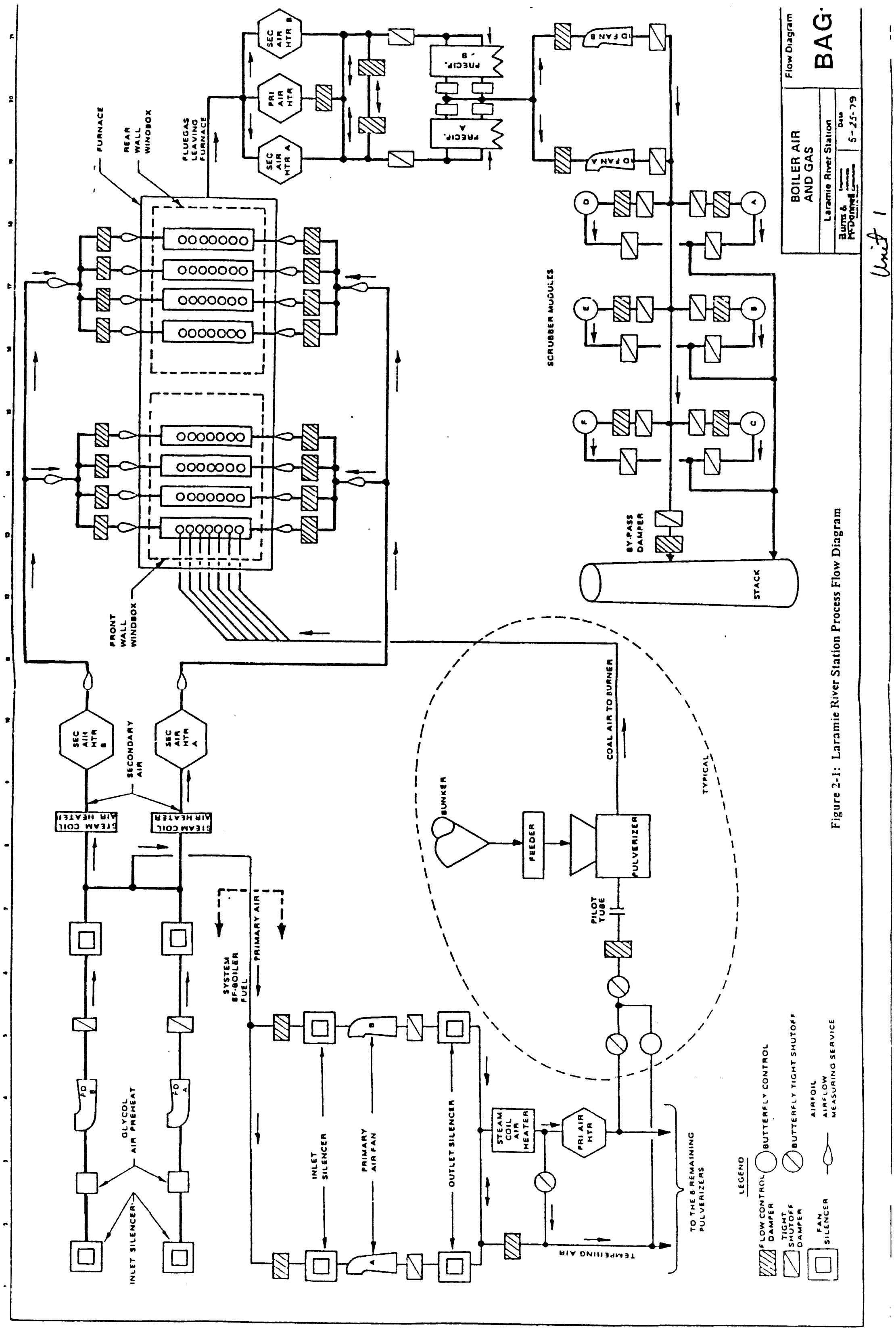
1. Sub-bituminous coal is delivered to the plant by unit train.
2. The coal is conveyed to the plant where it is pulverized.
3. The coal is combusted in the furnace using primary and secondary air.
4. The flue gas enters the precipitator where the particulates are removed.
5. The gas exits the precipitator and is blown into the scrubber.
6. The flue gas enters the scrubber and is sprayed with a limestone-water slurry.
7. The gas exits the scrubber and then the stack.

The LRS Unit 1 consists of a Babcock and Wilcox pulverized coal-fired boiler. The unit has a gross electric generation capacity of 600 MW. During the test, the average gross electric generation was 538 MW.

Sub-bituminous coal is supplied to the Laramie River Station by unit trains from the Buckskin, Rawhide, and Cordero mines. The coal is conveyed to the plant coalbunkers, where it is fed to the pulverizers. From the pulverizers, coal is blown into the furnace using primary air as the conveyor and secondary air as fuel combustion air. During the test, the average coal feed rate was 320.3 tons per hour (tph).

Flue gas from the unit's boiler flows to a Babcock and Wilcox electrostatic precipitator (ESP). From the ESP, an induced draft fan pushes the flue gas into the Research Cottrell flue gas desulferization system (scrubber). In the scrubber, the flue gas is sprayed with limestone-water slurry to remove sulfur dioxide. The cleaned flue gas is emitted from a 600-foot stack with a brick liner. The flue gas enters perpendicular to the stack. Continuous Emissions Monitoring Systems (CEMS) equipment is located on the 300 foot level of the stack.

Figure 2-1: Laramie River Station Process Flow Diagram



2.2 CONTROL EQUIPMENT DESCRIPTION

An electrostatic precipitator manufactured by Babcock and Wilcox controls particulate matter emissions from the boiler (furnace). The Scrubber is a Research Cottrell wet limestone scrubber consisting of six scrubber modules. The flue gas is blown into the scrubber where it is sprayed with a mixture of limestone and water.

Table 2-1 presents a summary of the normal ranges of operating parameters the Scrubber/ESP during the test.

Table 2-1: Scrubber/ESP Operating Parameters

Parameter	Normal Range
Volumetric Flow Rate	1.0-1.4mmscfm
Inlet SO_2 Concentration	200-550 ppm
Outlet SO_2 Concentration	40-80 ppm
Outlet SO_2 Mass Flow Rate	650-1150 lb/hr
Modules in service	6 SDA Chambers
% Slurry Solids	30-45%
Slurry Feed Rate	500-600 gpm
Scrubber Inlet Temp	250-300°F
Scrubber Outlet Temp	125-150°F
Lime to Sulfur Ratio	1.1-1.5

2.3 FLUE GAS SAMPLING LOCATIONS

Emissions sampling was conducted at (1) the inlet to the wet scrubber, and (2) the main stack. Figures 2-2 and 2-3 are schematics of these sampling locations.

2.3.1 Wet Scrubber Inlet. See Figure 4-1. The inlet duct is 29.5 feet wide and 23.0 feet deep, and is equipped with 8 sample ports, consisting of six inch threaded pipe nipples (with caps), approximately one foot long. One of the sample ports is occupied with an opacity monitor. At the sample port location, the duct is completely bisected in the vertical plane by a steel plate designed to provide structural rigidity. This arrangement essentially yields two ducts, each 11.5 feet deep and 29.5 feet wide.

Due to its proximity to the manifold and the presence of the bisecting vertical plate, the inlet location does not meet the port placement criteria of EPA Method 1. The Ontario-Hydro Method (Section 10.1.5) requires that sample be collected for not less than two hours, and not more than three hours. The method further requires that sample be collected for at least five minutes at each traverse point. Per the "Electric Utility Steam Generating Unit Mercury Emissions" web page; the furthest traverse point into the duct was approximately ten feet from the side of the duct.

Sampling was conducted at three traverse points in each of the seven ports (twenty one total points). In each of the seven test ports, sample was collected for six minutes per point at the following points:

Traverse Point Number	Distance From Inside Top Wall (inches)
1	23.5
2	70.5
3	117.5

Figure 2-2: Schematic of the LRS Unit 1 Inlet Sampling Location

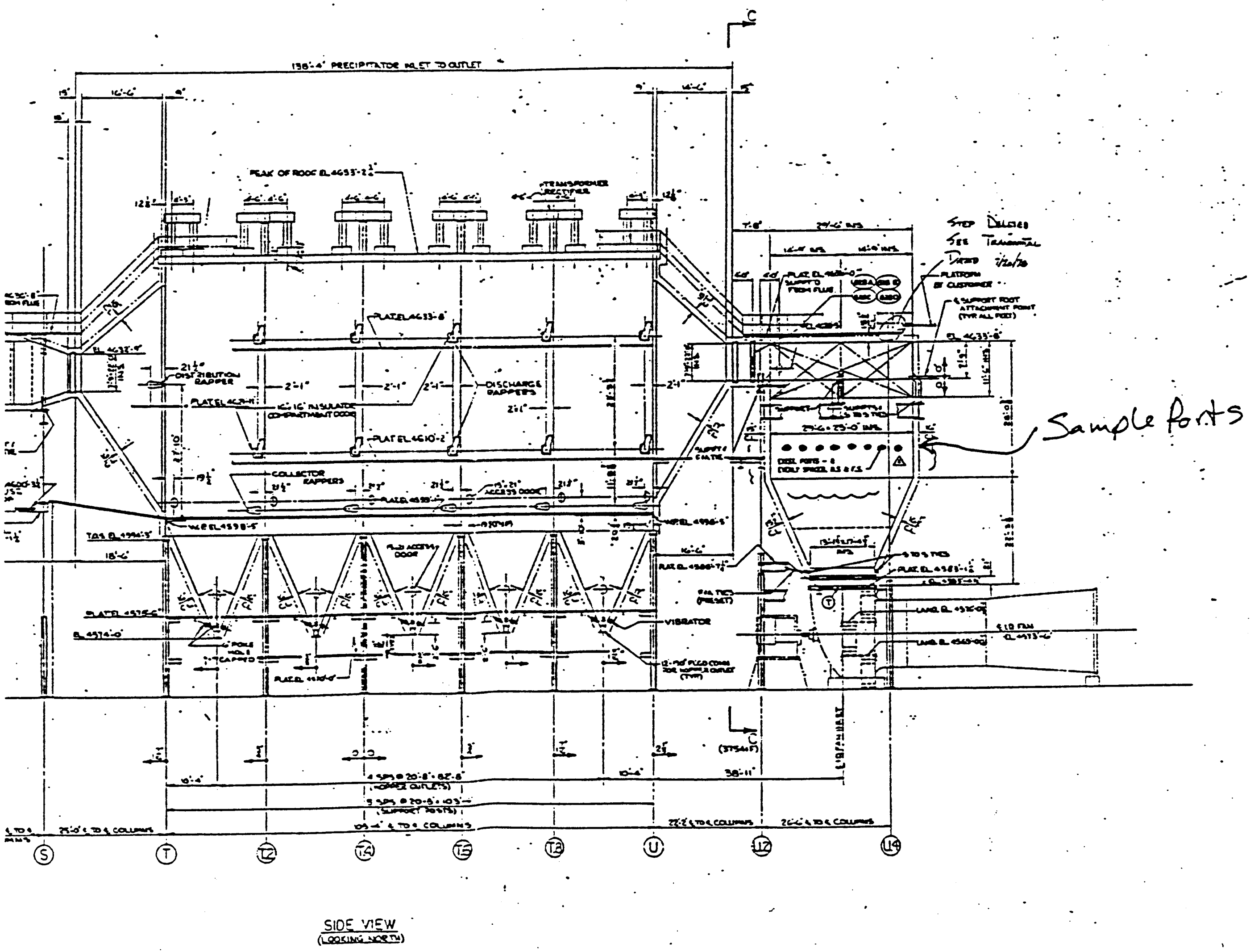
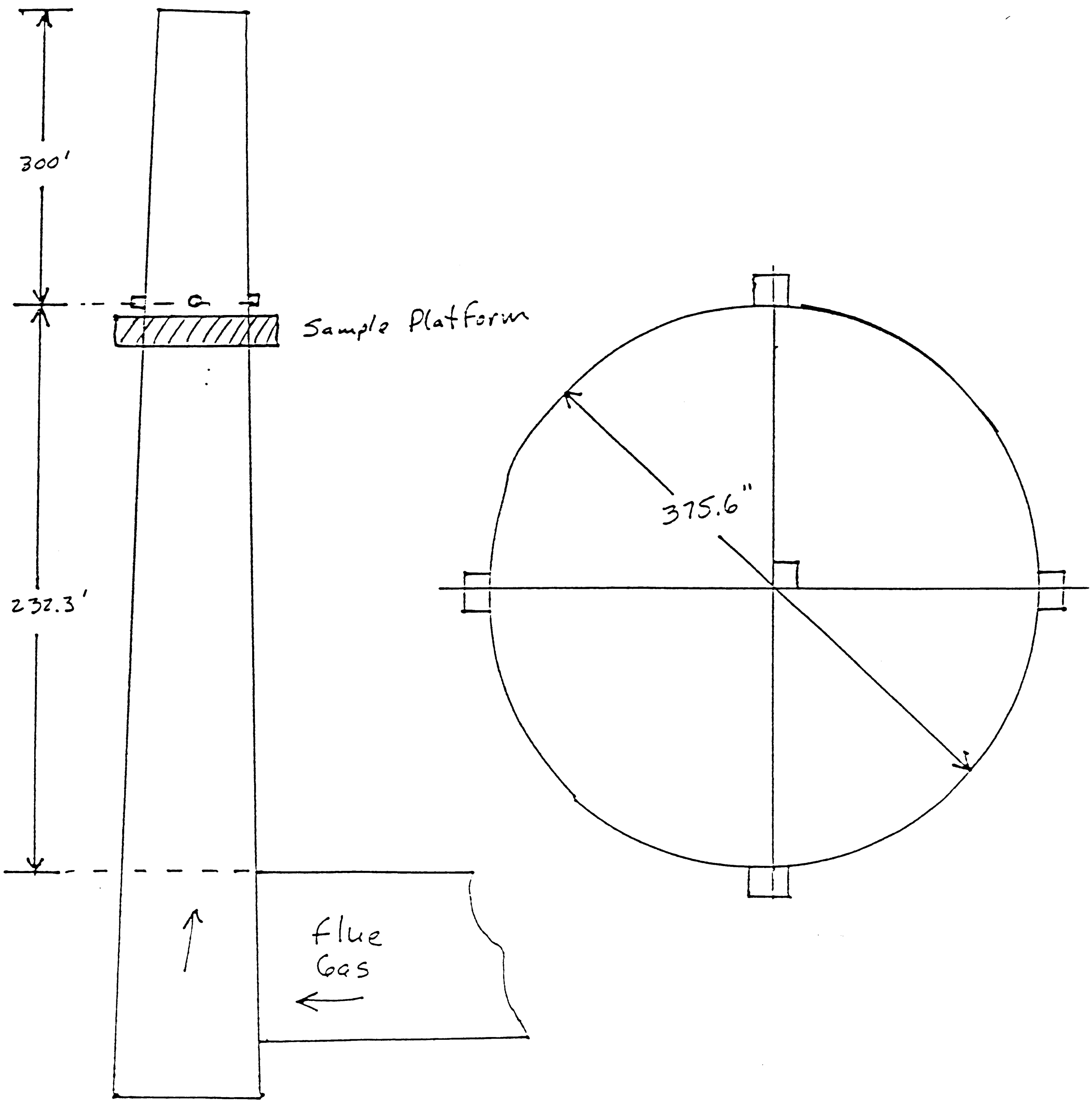


Figure 2-3: Schematic of the LRS Unit 1 Main Stack Sampling Location



The inlet sampling location did not meet the criteria of Method 1. Per the "Electric Utility Steam Generating Unit Mercury Emissions" web page, no modifications to the sampling procedure will be made, since ". . .(a) mercury is primarily in the gaseous phase and is not impacted by uncertainties in the gas flow and isokinetic sampling rate, and (b) stratification of mercury species is not expected."

2.3.2 Main Stack. See Figure 2-3. The diameter of the main stack at the sample location is 375.6 inches. The main stack is equipped with four 4" sample ports. The sample ports are located 232.3 feet (7.5 duct diameters) downstream of the flue gas entry to the stack, and 300 feet (9.6 duct diameters) upstream of the stack exit. Sampling was conducted at a total of twelve traverse points, three in each of the four ports. In each port, sample was collected for ten minutes per point, at the following points:

Traverse Point Number	Distance From Inside Wall (inches)
1	16.5
2	54.8
3	111.2

2.4 FUEL SAMPLING LOCATION

Fuel samples were collected at the inlet to the Gravimetric Coal feeders by diverting the sub-bituminous coal to a sampling container. The sample at this point was expected to be homogeneous.

3.0 SUMMARY AND DISCUSSION OF TEST RESULTS

3.1 OBJECTIVES AND TEST MATRIX

The purpose of the test program was to quantify mercury emissions from this unit. This information will assist the EPA Administrator in determining whether it is appropriate and necessary to regulate emissions of Hazardous Air Pollutants (HAPs) from electric utility steam generating units. The specific objectives, in order of priority were:

- Compare mass flow rates of mercury at the three sampling locations (fuel, inlet to and outlet of the scrubber/precipitator).

- During the test period, obtain process operating data: Gross MW, heat input (MMBtu/hr) and coal feed rate (tons per hour) and control equipment operating data: exhaust gas volumetric flow rate (SCFH), outlet SO_2, NO_x and CO_2 concentrations (ppm or %), SO_2 and NO_x emission rate (lb/hr), scrubber inlet SO_2 concentration (ppm), number of scrubber modules in service, % solids in the slurry feed, slurry feed rate (gal/min), scrubber inlet and outlet temperature, stack temperature, opacity.

Table 3-1 presents the sampling and analytical matrix and sampling log.

Table 3-1: Sampling Matrix

Run No.	Sample	Test	Location/Clock Time/Sampling Time	
Date	Type	Method	Inlet	Outlet
2 9/21/99	Speciated Mercury	Ontario Hydro	0902-1131 126	0902-1123 120
3 9/21/99	Speciated Mercury	Ontario Hydro	1226-1452 126	1226-1453 120
4 9/21/99	Speciated Mercury	Ontario Hydro	1640-1903 126	1640-1901 120

3.2 FIELD TEST CHANGES AND PROBLEMS

3.2.1 Inlet Sample Location. A post leak check conducted on test Run #1 indicated a leak rate in excess of the allowable 0.02 cfm. It was later determined that the leak in the sampling train had occurred at the outlet of the in-stack filter holder connection. The run was disallowed and one additional test run was conducted. The valid test runs are Run 2, Run 3 and Run 4.

3.2.2 Hydroxylamine Sulfate Solution. On July 9, 1999, Bruce Randall received a telephone call from the Energy and Environmental Research Center. The caller informed Mr. Randall that the recipe for this solution was to be revised such that equal amounts of Hydroxylamine Sulfate and Sodium Chloride were utilized. Mr. Randall verbally confirmed this change with Mr. Bill Grimley of EPA. This change was incorporated and utilized.

3.2.3 Outlet Sample Location. It was discovered after the third test run that there was an error in marking the sampling points on the sample probe. Jerry Menge from BEPC discussed this error with Bill Grimley of the EPA on September 22, 1999 (see letter presented in Appendix F). Mr. Grimley had stated that they do not believe the mercury is in a particulate state, so the isokinetics are only marginally important. Mr. Grimley also stated that the data should be valid and that no further testing should be required unless there was a big deviation in the test results. The probe was remarked and sampling continued for Run 4. Flow comparisons and laboratory results were similar for Runs 2, 3 and 4 so no further testing was required.

3.3 PRESENTATION OF RESULTS

3.3.1 Mercury Mass Flow Rates. The mass flow rate of Mercury determined at each sample location is presented in Table 3-2.

Table 3-2: Summary of Results

Sample Location	Elemental Mercury (gram/hr)	Oxidized Mercury (gram/hr)	Particle-Bound Mercury (gram/hr)	Total Mercury (gram/hr)
Fuel				
Run 2				21.32
Run 3				22.06
Run 4				28.19
Average				**23.86**
ESP Inlet				
Run 2	10.70	4.48	0.36	15.54
Run 3	11.52	2.98	0.05	14.55
Run 4	10.49	4.29	0.02	14.80
Average	**10.90**	**3.91**	**0.14**	**14.96**
Main Stack				
Run 2	6.80	0.41	0.03	7.17
Run 3	8.04	0.17	0.00	8.21
Run 4	7.66	0.05	0.01	7.72
Average	**7.48**	**0.21**	**0.01**	**7.70**

3.3.2 Comparison of Volumetric Flow Rate. Volumetric flow rate is a critical factor in calculating mass flow rates. Ideally, the volumetric flow rate (corrected to standard pressure and temperature) measured at the inlet to the control device should be the same as that measured at the stack, which should be the same as that measured by the CEMS. As can be seen in Table 3-3, agreement between the three locations on a thousand standard cubic foot per minute basis (KSCFM) was quite good.

Table 3-3: Comparison of Volumetric Flow Rate Data

	Inlet KACFM/KSCFM/KDSCFM	Stack KACFM/KSCFM/KDSCFM	CEMS KSCFM
Run 2	2,730/1,574/1,372	2,221/1,650/1,398	1,664
Run 3	2,620/1,522/1,341	2,131/1,587/1,351	1,597
Run 4	2,622/1,529/1,353	2,186/1,629/1,374	1,600
Average	2,657/1,542/1,355	2,179/1,622/1,374	1,620

The measured volumetric flow rate (KSCFM) at the inlet was approximately 5% lower than that measured at the stack. The measured volumetric flow rate at the stack (KSCFM) was approximately 0.1% higher than that determined by the CEMS. Percent differences of this magnitude should be considered to be very good, and indicate that mass flow rates of mercury calculated based on this data should be representative.

3.3.3 Individual Run Results. A detailed summary of results for each sample run at the inlet and main stack are presented in Tables 3-4 and 3-5, respectively.

Table 3-4: Inlet Individual Run Results

Parameter	Run 2	Run 3	Run 4	Average
Sample Date	09/21/99	09/21/99	09/21/99	
Clock Time	0902-1131	1226-1452	1640-1903	
Sample Time	126	126	126	126
Average Duct Temperature (oF)	286	281	277	281
Average Duct Velocity (ft/s)	67.1	64.4	64.4	65.3
Moisture Content (%vol)	12.8	11.9	11.6	12.1
CO_2 Content (%vol dry)	10.4	10.4	9.8	10.2
O_2 Content (%vol dry)	10.0	10.1	10.1	10.1
Fo	1.048	1.038	1.102	1.063
Wet Molecular Weight (g/g-mole)	28.51	28.64	28.59	28.58
Volume Flow Rate (ACFM)	2730010	2619690	2621720	2657140
Volume Flow Rate (SCFM)	1573760	1521620	1529480	1541620
Volume Flow Rate (DSCFM)	1371660	1341130	1352890	1355227
Coal Feed Rate (ton/hr)	331	316	314	320
Coal Hg Content (mg/kg, dry basis)	0.103	0.111	0.144	0.119
Sample Volume (dscf)	84.578	83.837	85.140	
Net Elemental Hg (µg)	11.00	12.00	11.00	11.33
Net Oxidized Hg (µg)	4.60	3.10	4.50	4.07
Net Particle-Bound Hg (µg)	0.37	0.06	0.025	0.15
Total Hg (µg)	15.97	15.16	15.53	15.55
Elemental Hg ER (gram/hr)	10.70	11.52	10.49	10.90
Oxidized Hg ER (gram/hr)	4.48	2.98	4.29	3.91
Particle-Bound Hg (gram/hr)	0.36	0.05	0.02	<0.14
Total Hg (gram/hr)	15.55	14.55	14.80	14.97
Sample Percentage of Isokinetic (%)	96.6	98.0	98.6	

Table 3-5: Main Stack Individual Run Results

Parameter	Run 2	Run 3	Run 4	Average
Sample Date	09/21/99	09/21/99	09/21/99	
Clock Time	0902-1123	1226-1453	1640-1901	
Sample Time	120	120	120	120
Average Duct Temperature (oF)	148	146	146	147
Average Duct Velocity (ft/s)	48.1	46.2	47.4	47.2
Moisture Content (%vol)	15.2	14.9	15.7	15.3
CO_2 Content (%vol dry)	10.0	10.3	11.8	10.7
O_2 Content (%vol dry)	10.5	10.0	7.8	9.4
Fo	1.040	1.058	1.110	1.069
Wet Molecular Weight (g/g-mole)	28.19	28.25	28.29	28.25
Volume Flow Rate (ACFM)	2220750	2130970	2186350	2179357
Volume Flow Rate (SCFM)	1649840	1587280	1629420	1622180
Volume Flow Rate (DSCFM)	1398490	1350830	1373790	1374370
Coal Feed Rate (ton/hr)	331	316	314	320
Coal Hg Content (mg/kg, dry basis)	0.103	0.111	0.144	0.119
Sample Volume (dscf)	84.709	83.719	83.845	
Net Elemental Hg (µg)	6.80	8.30	7.80	7.63
Net Oxidized Hg (µg)	0.41	0.17	0.05	0.21
Net Particle-Bound Hg (µg)	0.03	0.005	0.01	0.02
Total Hg (µg)	7.24	8.48	7.86	7.86
Elemental Hg ER (gram/hr)	6.73	8.04	7.67	7.48
Oxidized Hg ER (gram/hr)	0.41	0.17	0.05	0.21
Particle-Bound Hg (gram/hr)	0.03	0.00	0.01	0.01
Total Hg (gram/hr)	7.17	8.21	7.73	7.70
Sample Percentage of Isokinetic (%)	94.2	96.3	94.9	

3.3.4 Process Operating Data. The process operating data collected during the tests is presented in Table 3-6.

Table 3-6: Process Operating Data

Parameter	Run 2	Run 3	Run 4	Average
Date	09/21/99	09/21/99	09/21/99	
Start-End Time	0902-1134	1226-1452	1640-1904	
Volume Flow Rate (KSCFM)	1,664	1,597	1,600	1,620
Inlet SO_2 (ppm wet)	392	406	404	400
Stack SO_2 (ppm wet)	56.2	59.4	58.4	58.0
Stack SO_2 (lb/hr)	953.6	968.1	953.2	962.4
Scrubber Modules in Service	4	4	4	4
Slurry Solids Density	1.162	1.162	1.162	1.162
Slurry Feed Rate (gpm)	NA	NA	NA	NA
Inlet Temperature(°F)	284	277	276	279
Stack Temperature (°F)	154	149	149	151
Gross Megawatts	554	529	529	538
Stack NOx (ppm wet)	116.3	110.7	111.5	112.8
Stack NOx (lb/MMBtu)	0.23	0.22	0.22	0.22
Stack CO_2 (% vol wet)	10.5	10.5	10.5	10.5
Stack % Opacity (1 min avg.)	12	12	12	12
Coal Feed Rate (ton/hr)	331	316	314	320
Heat Input (MMBtu)	5974	5746	5734	5818

NA - Not Applicable

4.0 SAMPLING AND ANALYTICAL PROCEDURES

4.1 TEST METHODS

4.1.1 Speciated mercury emissions were determined via the draft "Standard Test Method for Elemental, Particle-Bound, and Total Mercury in Flue Gas Generated from Coal-Fired Stationary Sources (Ontario-Hydro Method)", dated April 8, 1999. Any revisions to this test method issued after April 8, 1999 but before July 1, 1999 were incorporated. The change in formula for the Hydroxylamine Sulfate recovery solution described in Section 3.2.2 of this report was the only change from the procedures proposed in the Site Specific Test Plan for this project.

The in-stack filtration (Method 17) configuration was utilized at the inlet location. The out-of-stack filtration (Method 5) configuration was utilized at the main stack. Figures 4-1 and 4-2 are schematics of the Ontario-Hydro sampling trains.

Figure 4-3 illustrates the sample recovery procedure. The analytical scheme was per Section 13.3 of the Ontario-Hydro Method.

Figure 4-1: Ontario-Hydro Sampling Train (Method 17 Configuration)

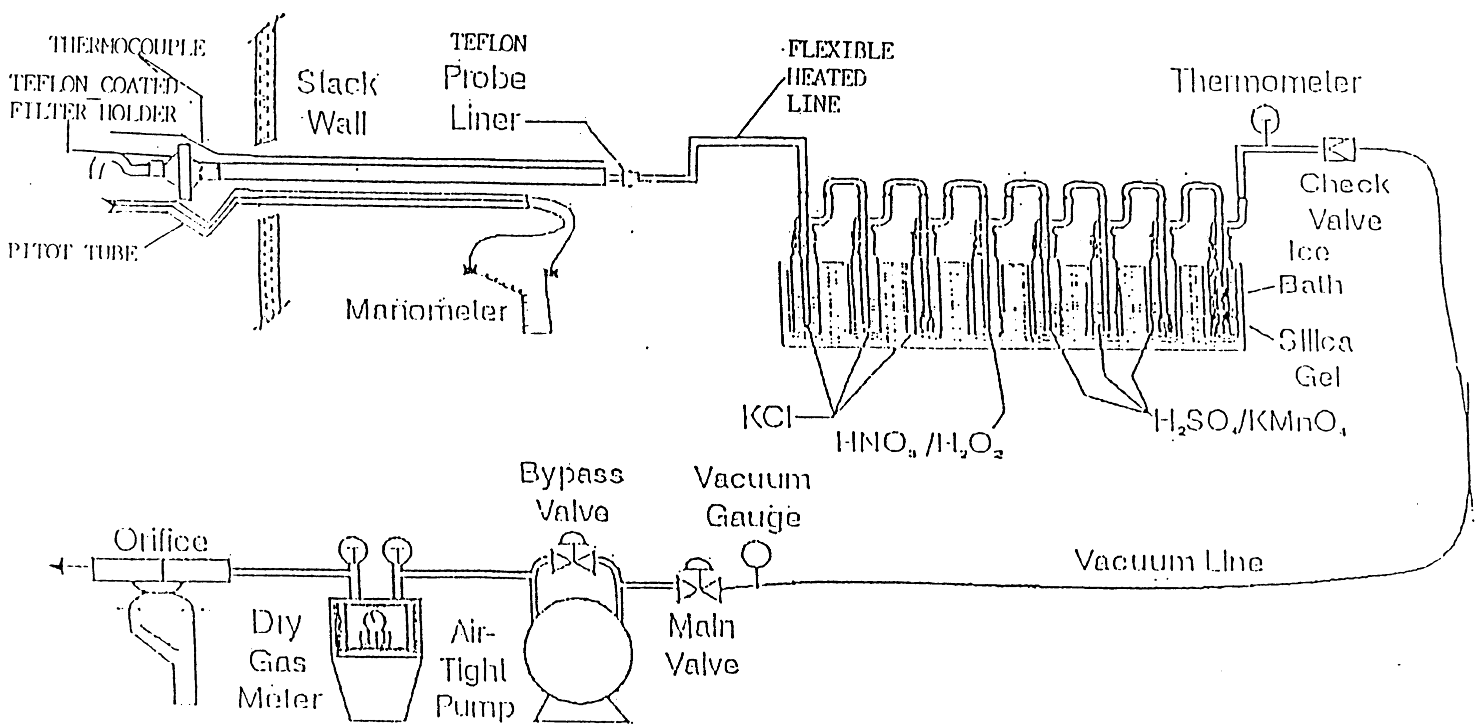


Figure 4-2: Ontario-Hydro Sampling Train (Method 5 Configuration)

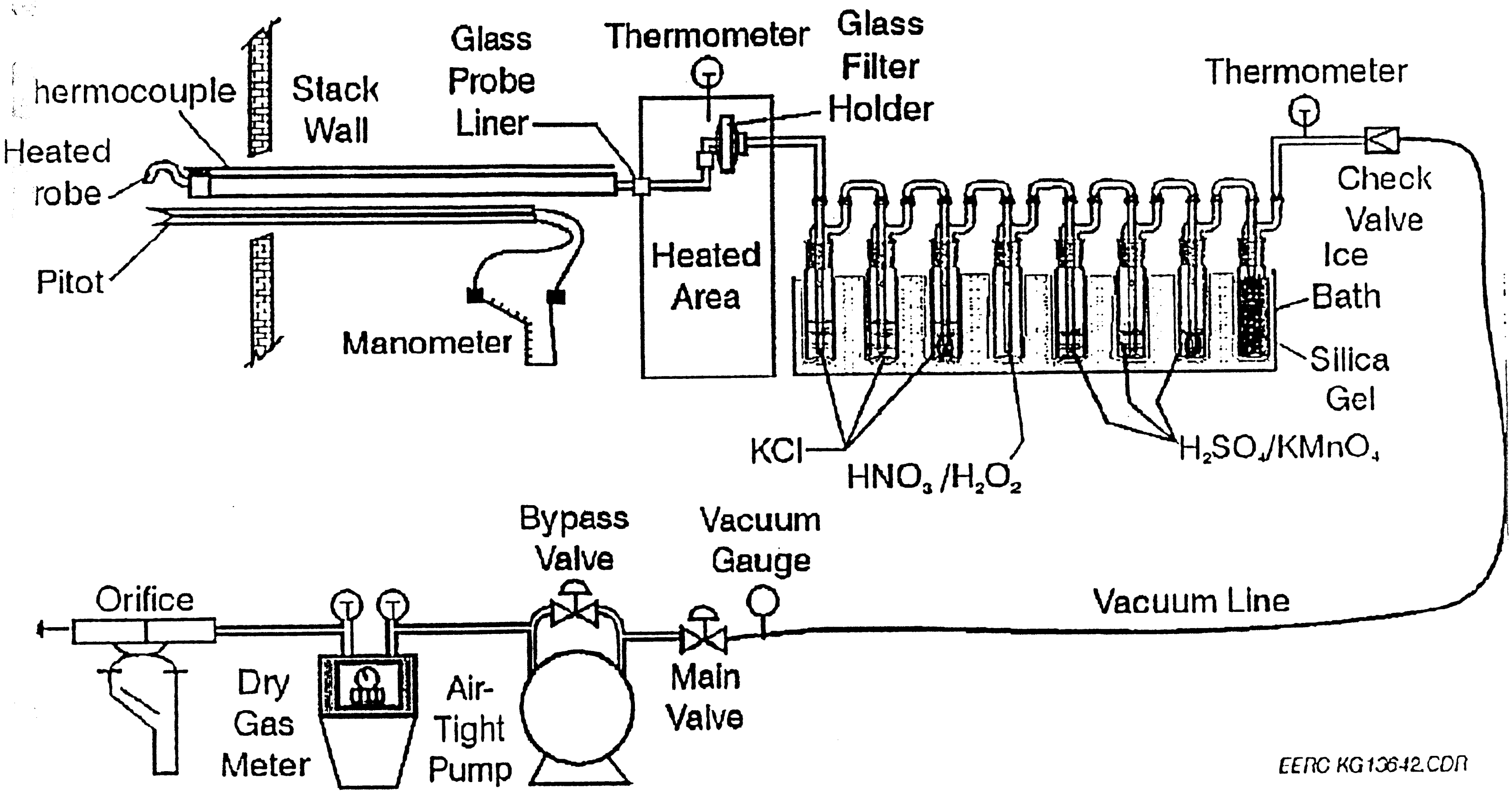
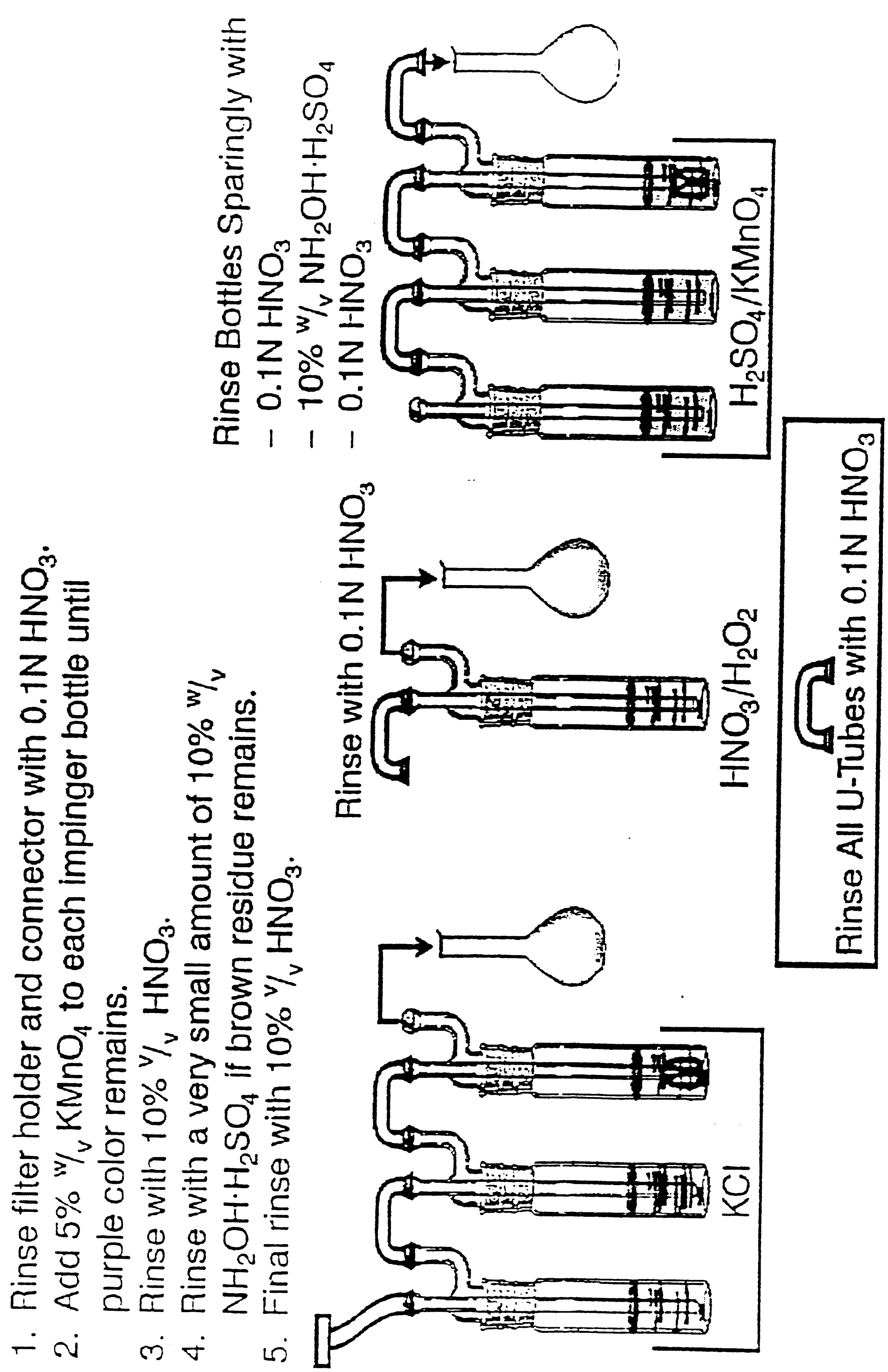


Figure 4-3: Sample Recovery Scheme for Ontario-Hydro Method Samples



5.0 INTERNAL QA/QC ACTIVITIES

5.1 QA/QC PROBLEMS

There were no QA/QC problems that occurred during these tests.

5.2 QA AUDITS

5.2.1 Reagent Blanks. As required by the method, blanks were collected for all reagents utilized. The results of reagent blank analysis are presented in Table 5-1.

Table 5-1: Reagent Blank Analysis

Container #	Sample Fraction	Contents	Mercury (μg)	Detection Limit (μg)
C7/C12	Front-half	0.1N HNO_3/Filter	<0.010	0.010
C8	1 N KCl	1 N KCl	<0.030	0.030
C9	HNO_3/H_2O_2	HNO_3/H_2O_2	<0.010	0.010
C10	$KMnO_4/H_2SO_4$	$KMnO_4/H_2SO_4$	<0.030	0.030

5.2.2 Blank Trains. As required by the method, blank trains were collected at both the inlet and stack sampling locations. These trains were collected on 09/20/99. The results of blank train analysis are presented in Table 5-2.

Table 5-2: Blank Train Analysis

Container #	Sample Fraction	Contents	Mercury (μg)	Detection Limit (μg)
IB C01/C02	Front-half	Filter/front-half rinse	<0.050	0.010
SB C01/C02	Front-half	Filter/front-half rinse	<0.010	0.010
IB C03	KCl impingers	Impingers/rinse	<0.10	0.030
SB C03	KCl impingers	Impingers/rinse	<0.10	0.030
IB C04	HNO_3-H_2O_2 impingers	Impingers/rinse	<0.25	0.010
SB C04	HNO_3-H_2O_2 impingers	Impingers/rinse	<0.25	0.010
IB C05	$KMnO_4/H_2SO_4$ impingers	Impingers/rinse	<0.10	0.030
SB C05	$KMnO_4/H_2SO_4$ impingers	Impingers/rinse	<0.10	0.030

5.2.3 Field Dry Test Meter Audit. The field dry test meter audit described in Section 4.4.1 of Method 5 was completed prior to the test. The results of the audit are presented in Table 5-3.

Table 5-3: Field Meter Audit

Meter Box Number	Pre-Audit Value	Allowable Error	Calculated Yc	Acceptable
81231	0.999	0.9690<Yc<1.0290	1.014	Yes
80573	0.996	0.9661<Yc<1.0259	0.995	Yes